Adjunctive use of the superficial femoral vein for vascular reconstructions

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Objective: **Although the superficial femoral vein (SFV) is an accepted treatment for aortic graft infections, this conduit also has potential uses in other areas. Herein, we evaluate our experience using the SFV for arterial and venous bypasses and the arteriovenous (AV) fistula for dialysis access.**

Methods: **Between 1999 and 2011, 42 patients underwent a bypass or a thigh AV fistula using the SFV (31 arterial, four central venous, six AV fistulas, and one common carotid-to-vertebral bypass). Indications for arterial bypass included infected graft (20), critical limb ischemia (nine), and failed bypass (six). Indications for central venous bypass were: superior vena cava syndrome (two), vessel reconstruction due to tumor encasement (one), and central vein occlusion from thoracic outlet syndrome (one). All AV fistulas were created after patients sustained bilateral subclavian vein occlusions from failed upper extremity access. The common carotid-to-vertebral bypass was created due to an occluded vertebral artery with resultant stroke.**

Results: **Kaplan-Meier cumulative patency curves were used. The primary patency rates at 30 days, 1 year, and 3 years were 97.4% (95% confidence interval [CI], 92.41-100), 74.6% (95% CI, 57.89-96.23), and 66.4% (95% CI, 47.06-93.53), respectively. The assisted primary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 97.1% (95% CI, 91.54-100), and 89% (95% CI, 74.29-100), respectively. Secondary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 97.1% (95% CI, 91.54-100), and 89% (95% CI, 74.29-100), respectively. Limb salvage rates at 30 days, 1 year, and 3 years were 97.3% (95% CI, 92.21-100), 93.6% (95% CI, 78.35-100), and 93.6% (95% CI, 78.35-100), respectively. Survival rates at 30 days, 1 year, and 3 years were 97.6% (95% CI, 92.95-100), 86% (95% CI, 75.3-98.3), and 86% (95% CI, 75.3-98.3), respectively. Follow-up ranged from 1 month to 8.7 years (mean time, 21 months). Complications occurred in 22 patients (52%) and included wound complications (n = 19; 45.2%); deep vein thrombosis (n = 1; 2.4%); anastomotic breakdown (n = 1; 2.4%); hematoma (n = 4; 9.5%); pulmonary embolism (n = 2; 4.8%); and compartment syndrome (n = 2; 4.8%).**

Conclusions: **The SFV is a durable conduit for uses beyond aortic reconstruction and should be considered when the great saphenous vein is not available or size match is a concern. However, wound complications remain a problem. (J Vasc Surg 2012;55:1355-62.)**

The superficial femoral vein (SFV) has proven to be a successful arterial conduit in the treatment of arterial insufficiency and more commonly of prosthetic graft infections. Schulman et al[1-3] demonstrated that the SFV could be used as an alternate conduit for femoral-popliteal arterial bypass with patency rates comparable to the great saphenous vein (GSV). Another common use for the SFV has been in constructing the neoaortoiliac system to treat prosthetic aortofemoral graft infections. Studies by Clagett et al[4,5] have shown that the neoaortoiliac system is also associated with excellent patency rates.

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Despite the suitability of this conduit, there have been concerns for venous morbidity in the donor limb after SFV harvest. Coburn et al[6] found that deep vein harvest was associated with venous stasis edema, occasionally resulting in phlegmasia and limb loss. Multiple other studies, however, have demonstrated a low incidence of venous morbidity, which in most cases resolved over time, leaving minimal to no clinical disability.[1,2,4,5,7,8]

Given the durability and minimal morbidity of the SFV conduit in aortic and lower extremity (LE) reconstructions, we have used the SFV in other areas requiring autogenous conduits. In this study, we present our 12-year experience with the SFV as a conduit for vascular reconstructions, including nonaortic arterial and venous bypasses and arteriovenous (AV) fistula for dialysis access.

METHODS

This study was approved by our institutional board. Between 1999 and 2011, 42 patients underwent nonaortic SFV reconstructions. We performed a retrospective review of the patients' outcomes, which included morbidity and mortality, patencies, and limb salvage. We also analyzed the patients' demographics, indications for procedures, and operative details.[9]

Table I. Procedures

Procedure	*No. (42)*	*Emergent*	*Infected*	*Redo*
Lower extremity	31	18 (58.1%)	20 (64.5%)	27 (87.1%)
Cross-pelvic fem-fem bpg	10 (23.8%)			
Iliofemoral bpg	19 (45.2%)			
Fem-fem interposition bpg	2 (4.8%)			
Venous	4	0 (0%)	0 (0%)	0 (0%)
Axill/SVC-innominate bpg	3 (7.1%)			
Innominate-SVC bpg	1 (2.4%)			
Fistulas	6 (14.3%)	0 (0%)	0 (0%)	0 (0%)
Other	1	1 (100%)	0 (0%)	0 (0%)
CCA-vertebral bpg	1 (2.4%)			

Axill, Axillary; *bpg,* bypass; *CCA,* common carotid artery; *Fem-fem,* femoral to femoral bypass grafts; *SVC,* superior vena cava.

Our study population underwent 31 LE arterial reconstructions, four central venous bypasses, six AV fistulas, and one carotid-to-vertebral bypass (Table I). Indications for the LE arterial reconstructions included peripheral vascular disease (claudication, rest pain, and tissue loss), infected native vessel or graft, failed bypass, or tumor encasing an artery. Venous reconstructions were performed for superior vena cava (SVC) syndrome, tumor encasing a vein, and thoracic outlet syndrome. All fistulas were created for dialysis access, and the carotid-to-vertebral bypass treated a patient who had a cardiovascular accident secondary to an occluded vertebral artery. SFV was used in all the above reconstructions due to the absence or unsuitable nature (sclerotic or diameter <2.5 mm) of the GSV and arm veins. Generally, the deep vein was harvested if the GSV was patent on that side to prevent postoperative venous morbidity. For non-LE cases, SFV grafts were harvested from the leg with the higher ankle-brachial index. For LE reconstructions, the SFV was harvested mainly from the operative limb, because it could be done from the same incision. All LE grafts had inflow from either the iliac or femoral arteries, and the femoral artery was the most distal outflow vessel.

Patients who underwent elective surgery had a preoperative venous duplex ultrasound of their deep and superficial systems to assess the patency, size, and quality of the deep veins. For emergent cases, the quality of the deep vein was evaluated intraoperatively. All SFV conduits were harvested through an incision medial to the sartorius, and from just below the level of the common femoral vein and profunda bifurcation, to the above-knee popliteal vein. Venous branches were doubly ligated. Once harvested, the SFV was used in a reversed fashion as a single segment conduit. Valve lysis was at the discretion of the surgeon and not routinely documented. An example of one of our SFV conduits can be seen in Fig 1.

All fistulas were created using a transposition technique as described by Jackson.[10] The SFV was harvested from the common femoral vein down to the above-knee popliteal vein. The SFV was ligated and transected distally, tunneled on the medial anterior thigh, and anastomosed to the superficial femoral artery in an end-to-side fashion.

Postoperative surveillance was performed on all grafts using duplex scan imaging. All patients underwent graft surveillance and pulse volume recordings at 1 month, every 3 months for the first year, and every 6 months thereafter. Patients underwent angiography if the ankle-brachial index decreased by more than 0.15, or the peak systolic velocity ratio between adjoining segments was greater than four. Therapeutic interventions, such as angioplasty, stent placement, or surgery were performed when appropriate.

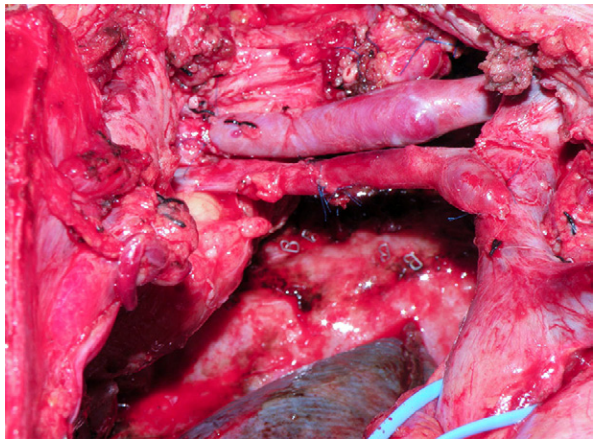

Fig 1. Example of superficial femoral vein (SFV) interposition grafts for a patient who had a tumor encasing her subclavian vein and artery.

Statistical analysis. Categorical factors were described using frequencies and percentages, whereas continuous measures were described using means, SDs, medians, and ranges, as appropriate. To estimate rates of patency, limb salvage, and survival, Kaplan-Meier estimates were calculated overall and by treatment group. Point estimates for each measure are presented with 95% confidence intervals (CIs). Analyses were performed using 9.1 software (SAS Institute, Cary, NC) and R 2.8 software (Vienna, Austria).

RESULTS

Our study population consisted of 42 patients, of which 22 were men (52.4%) and 20 were women (47.6%) with an average age of 62.5 ± 13.2 years. Thirty-two were white (76.2%) and 10 were black (23.8%). The most prevalent

Table II. Demographics and comorbidities (all patients)

	No. (42)	*Percentage*
Age	62.5 ± 13.2	
Gender (male)	22	52.4
Race		
White	32	76.2
African American	10	23.8
BMI	27 ± 5.0	
Tobacco	15	35.7
Hypertension	35	83.3
CAD	23	54.8
Diabetes	15	35.7
Hyperlipidemia	29	69.0
COPD	10	23.8
Renal failure	12	28.6

BMI, Body mass index; *CAD,* coronary artery disease; *COPD,* chronic obstructive pulmonary disease.

Rutherford RB, Baker JD, Ernst C, Johnston KW, Porter JM, Ahn S, et al. Recommended standards for reports dealing with lower extremity ischemia: revised version. J Vasc Surg 1997;26:517-38.

comorbidities among this group of patients were hypertension (35; 83.3%), hyperlipidemia (29; 69.0%), and coronary artery disease (23; 54.8%; Table II).

Indications for an LE arterial bypass included: infected native vessel/graft (20; 64.5%), ischemia (11; 35.5%), failed bypass (6; 19.3%), and tumor encasement of vessels (one; 3.2%). Of the LE cases, 18 patients (58.1%) were emergent and 27 patients (87.1%) underwent redo surgery. Central venous bypasses were performed for SVC syndrome (two; 50.0%), tumor encasement of deep veins (one; 25.0%), and thoracic outlet syndrome (one; 25.0%). All fistulas were performed for dialysis access. The carotid-to-vertebral bypass was performed for a cardiovascular accident secondary to an occluded vertebral artery. Of patients with an infection, staphylococcus (eight; 40.0%) was the most common organism cultured, followed by enterococcus (three; 15.0%) and pseudomonas (three; 15.0%). The remaining six patients had no growth seen on their cultures. The diameter of SFV grafts evaluated preoperatively in patients with nonemergent LE was 8.5 mm ± 1.8 mm (n = 13). SFV diameters were not available for the other types of reconstructions.

Wound problems were the most common complication across all four categories of procedures. Among patients who underwent LE procedures, nine (29.0%) had wound complications in the first 30 days, and an additional four patients developed late wound problems (total 13; 41.9%). The specific types of wound complications included two seromas (groin and harvest site) that were managed conservatively; two infected groin lymphoceles treated with sartorius and rectus femoris muscle flaps and wound debridement; seven wound dehiscences (four involving the harvest site) that were managed conservatively; two wound necroses that were managed with debridement and dressings; and one nonhealing fasciotomy wound in the harvest limb treated by improving arterial circulation to that limb (superficial femoral artery/profunda endarterectomies). Wound complications mainly involved the operative incision (10 patients) vs the harvest site (three patients). Additionally, nine of the 13 patients with wound complications had a previously infected groin wound. Five patients who underwent the other three procedures (venous, fistula, and other) had minor wound complications, including dehiscence and minimal skin necrosis, managed effectively with conservative measures; the majority involving the harvest site (three of five patients; Table III).

Deep vein thrombosis (DVT) and pulmonary embolism were seen in two patients who underwent LE procedures. Both patients were treated successfully with oral anticoagulation. The patient with a DVT had undergone an iliofemoral bypass and developed his DVT in the operative limb, which was also the donor limb (Table III).

Four patients suffered a postoperative hematoma (all of whom underwent LE bypass) requiring operative evacuation. Causes for hematomas included bleeding side branch of the SFV graft (n = 1) and small arterial bleeders, unrelated to the graft (n = 3; Table III).

Anastomotic rupture occurred in one patient who had squamous cell cancer that encased his femoral vessels. He underwent resection of the tumor, which included the femoral artery, followed by femoral artery reconstruction with ipsilateral SFV and a rectus femoris muscle flap. Two weeks after the index procedure, he had necrosis of the muscle flap, which led to desiccation of the underlying SFV graft and subsequent blowout in one area of the anastomosis. Pressure was then held over the graft for hemostasis causing thrombosis. Consequently, the patient underwent operative thrombectomy and revision of the graft. Ten days after this revision, he again developed exsanguinating hemorrhage from the graft, requiring both vein graft ligation and hip disarticulation (Table III).

Compartment syndrome occurred in two patients. The first patient developed a tight anterior compartment intraoperatively with elevated creatine phosphokinases during creation of an iliofemoral SFV bypass graft. He underwent release of the anterior, lateral, and superficial posterior compartments intraoperatively. The second patient developed compartment syndrome on the first postoperative day in the calf of the harvest limb, requiring four-compartment fasciotomy. This was performed in both patients due to reperfusion injury. Both patients convalesced with no further problems (Table III).

Of patients undergoing fistula creation, one patient had steal syndrome. This was corrected by performing a distal revascularization and interval ligation procedure as a femoral above-knee popliteal artery bypass. Subsequently, the patient had no further issues.

Late venous morbidity, including chronic venous changes or venous claudication, was not seen in any of our patients.

Outcomes. Overall Kaplan-Meier cumulative patency curves are shown in Fig 2. The primary patency rates at 30 days, 1 year, and 3 years were 97.4% (95% CI, 92.41-100), 74.6% (95% CI, 57.89-96.23), and 66.4% (95% CI, 47.06-93.53), respectively. The assisted primary patency rates at

Table III. Complications

	All (42)		*LE (31)*		*Venous (4)*		*Fistulas (6)*		*Other (1)*	
Complication	*30 Days (%)*	*All (%)*	*30 Days (%)*	*All (%)*	*30 Days (%)*	*All (%)*	*30 Days (%)*	*All (%)*	*30 Days (%)*	*All (%)*
Wound complication	14 (33.3)	19 (45.2)	9 (29.0)	13 (41.9)	2 (50.0)	2 (50.0)	2 (33.3)	3 (50.0)	1 (100)	1 (100)
DVT	1 (2.4)	1 (2.4)	1 (3.2)	1 (3.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Anastomotic breakdown	1 (2.4)	1 (2.4)	1 (3.2)	1 (3.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Hematoma	4 (9.5)	4 (9.5)	4 (9.5)	4 (9.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
PE	1 (2.4)	2 (4.8)	1 (3.2)	2 (6.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Compartment syndrome	2 (4.8)	2 (4.8)	2 (6.5)	2 (6.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

DVT, Deep vein thrombosis; *LE,* lower extremity; *PE,* pulmonary embolism.

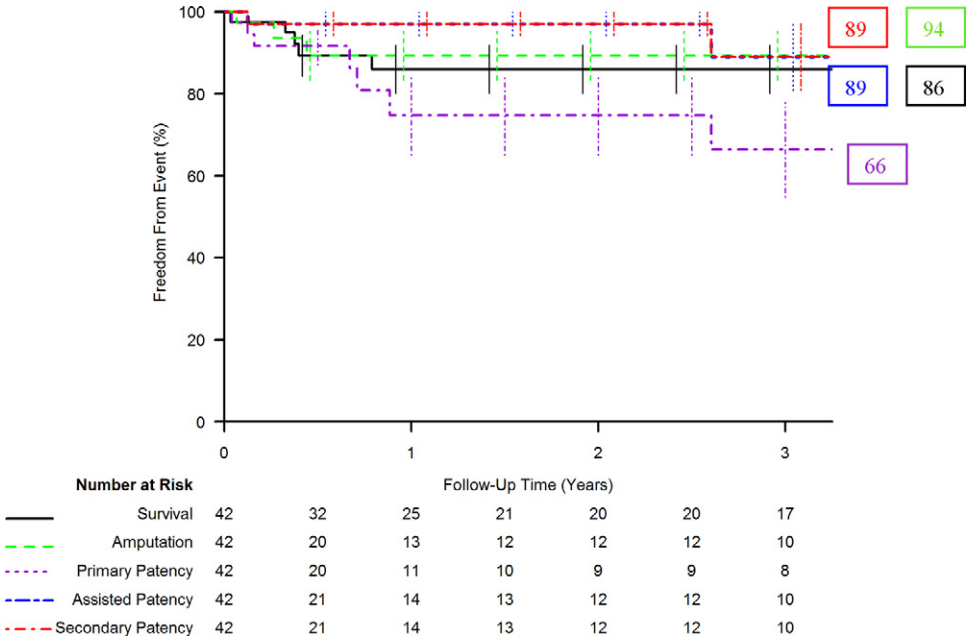

Fig 2. Three-year Kaplan-Meier estimates for survival, limb salvage, primary, assisted primary, and secondary patencies for all patients.

30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 97.1% (95% CI, 91.54-100), and 89.0% (95% CI, 74.29-100), respectively. Secondary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 97.1% (95% CI, 91.54-100), and 89.0% (95% CI, 74.29-100), respectively.

The patients who underwent LE procedures had primary patency rates at 30 days, 1 year, and 3 years of 96.3% (95% CI, 89.43-100), 88.3% (95% CI, 73.29-100), and 88.3% (95% CI, 73.29-100), respectively. The assisted primary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 100% (95% CI, 100-100), and 100% (95% CI, 100-100), respectively. Secondary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 100% (95% CI, 100-100), and 100% (95% CI, 100-100), respectively (Table IV, Fig 3).

For patients who underwent venous procedures, primary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 50.0% (95% CI, 18.77-100), and 25.0% (95% CI, 4.58-100), respectively. The assisted primary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 75.0% (95% CI, 42.59-100), and 50.0% (95% CI, 18.77-100), respectively. Secondary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 75.0% (95% CI, 42.59-100), and 50.0% (95% CI, 18.77-100), respectively (Table IV).

For patients who underwent fistula creation, primary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), not applicable (N/A), and N/A, respectively. The assisted primary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 100% (95% CI, 100-100), and 100% (95% CI, 100-100), respectively. Sec-

Table IV. Kaplan-Meier estimates of all outcomes

Procedures	*Primary patency*	*Assisted primary patency*	*Secondary patency*	*Limb salvage*	*Survival*
All					
1 month	97.4 (92.41-100)	100 (100-100)	100 (100-100)	97.3 (92.21-100)	97.6 (92.95-100)
12 months	74.6 (57.89-96.23)	97.1 (91.54-100)	97.1 (91.54-100)	93.6 (85.18-100)	86.0 (75.3-98.3)
36 months	66.4 (47.06-93.53)	89.0 (74.29-100)	89.0 (74.29-100)	93.6 (85.18-100)	86.0 (75.3-98.3)
LE					
1 month	96.3 (89.43-100)	100 (100-100)	100 (100-100)	96.2 (89.04-100)	96.7 (90.45-100)
12 months	88.3 (73.29-100)	100 (100-100)	100 (100-100)	90.5 (78.55-100)	84.0 (70.52-99.98)
36 months	88.3 (73.29-100)	100 (100-100)	100 (100-100)	90.5 (78.55-100)	84.0 (70.52-99.98)
Venous					
1 month	100 (100-100)	100 (100-100)	100 (100-100)	100 (100-100)	100 (100-100)
12 months	50.0 (18.77-100)	75.0 (42.59-100)	75.0 (42.59-100)	100 (100-100)	100 (100-100)
36 months	25.0 (4.58-100)	50.0 (18.77-100)	50.0 (18.77-100)	100 (100-100)	100 (100-100)
Fistulas					
1 month	100 (100-100)	100 (100-100)	100 (100-100)	100 (100-100)	100 (100-100)
12 months	0[a] (0-0)	100 (100-100)	100 (100-100)	100 (100-100)	83.3 (58.27-100)
36 months	0[a] (0-0)	100 (100-100)	100 (100-100)	100 (100-100)	83.3 (58.27-100)
Other					
1 month	100 (100-100)	100 (100-100)	100 (100-100)	100 (100-100)	100 (100-100)
12 months	N/A[b]	N/A[b]	N/A[b]	N/A[b]	100 (100-100)
36 months	N/A	N/A	N/A	N/A	N/A

LE, Lower extremity; *N/A,* not applicable.
[a]A patency, limb salvage, or survival estimate of 0 indicates that no patients are at risk at the time point and that the last patient followed failed, so that the final rate is 0.
[b]A patency, limb salvage, or survival estimate of N/A indicates that no patients are at risk at the time point and that the last patient being followed was censored, so that the rate at the given time point is not estimable.

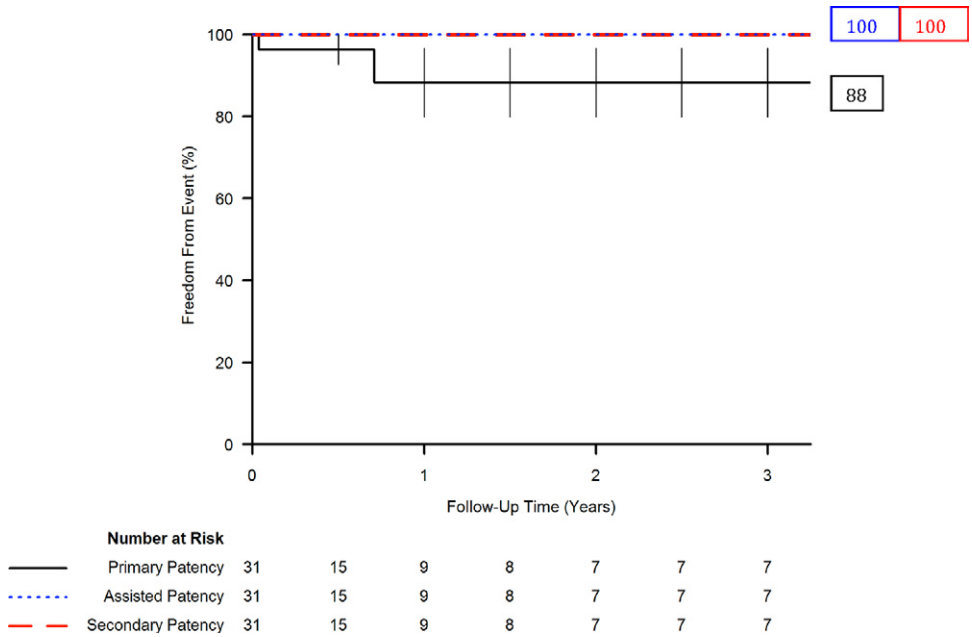

Fig 3. Three-year Kaplan-Meier estimates for primary, assisted primary, and secondary patencies for patients who underwent lower extremity (LE) reconstructions.

ondary patency rates at 30 days, 1 year, and 3 years were 100% (95% CI, 100-100), 100% (95% CI, 100-100), and 100% (95% CI, 100-100), respectively (Table IV).

The patient who underwent a common carotid artery (CCA)-vertebral bypass was patent at 5 months. A comparison of patency rates with log-rank between the various indication groups was not valid due to the small number of events.

Patients who underwent therapeutic interventions for graft patency included both open and endovascular proce-

dures. One LE reconstruction, one fistula, and one venous reconstruction required balloon angioplasty for vein graft stenosis found on surveillance. In the first two cases, angioplasty was sufficient; these patients required no further interventions to maintain patency. The venous reconstruction required placement of a self-expanding stent in addition to angioplasty for complete resolution of the stenosis. In terms of operative procedures, one LE patient underwent thrombectomy of the graft and one fistula patient required a patch angioplasty revision. The details of the intervention for the LE patient are mentioned above in the Results section. The fistula patient underwent patch angioplasty with a bovine pericardial patch. The graft remained patent after this operative intervention.

Overall limb salvage rates at 30 days, 1 year, and 3 years were 97.3% (95% CI, 92.21-100), 93.6% (95% CI, 85.18-100), and 93.6% (95% CI, 85.18-100), respectively. For patients who underwent LE procedures, limb salvage rates at 30 days, 1 year, and 3 years were 96.2% (95% CI, 89.04-100), 90.5% (95% CI, 78.55-100), and 90.5% (95% CI, 78.55-100), respectively. For patients who underwent all other types of procedures, limb salvage rates were 100% at 1 month, 1 year, and 3 years (Table IV).

Overall survival rates at 30 days, 1 year, and 3 years were 97.6% (95% CI, 92.95-100), 86.0% (95% CI, 75.3-98.3), and 86.0% (95% CI, 75.3-98.3), respectively. For patients who underwent LE procedures, survival rates at 30 days, 1 year, and 3 years were 96.7% (95% CI, 90.45-100), 84.0% (95% CI, 70.52-99.98), and 84.0% (95% CI, 70.52-99.98), respectively. For patients who underwent fistula creation, survival rates at 30 days, 1 year, and 3 years were 100.0% (95% CI, 100-100), 83.33% (95% CI, 58.27-100), and 83.33% (95% CI, 58.27-100), respectively. Patients who underwent venous procedures and the CCA-vertebral bypass all had 100% survival rates 1 month, 1 year, and 3 years (Table IV). Follow-up of the study group ranged from 1 month to 8.7 years (mean time, 21 months ± 28.2). Twenty-one patients were followed for a period >6 months. Seven deaths occurred over 8.7 years. Five of these deaths occurred within the first year and were due to cardiac arrest (one), congestive heart failure exacerbation (one), multisystem organ failure from a previously infected graft (one), and two of unknown causes. The other two patients died at 5 years (cause unknown) and 8 years (complete heart block) postsurgery. All patients had patent SFV grafts at the time of their death.

DISCUSSION

Our series has shown that the SFV can be a versatile conduit for both arterial and venous reconstructions when the GSV is unavailable or of poor quality. Although our results corroborate and expand on existing literature, we intended to also demonstrate some unconventional uses of the SFV that have rarely been studied. Some of the earliest evidence supporting the use of SFV came from three studies conducted by Schulman et al.[1-3] They focused on the use of SFV for femoral-popliteal bypass grafts. The main tenets guiding their operative technique included profunda vein preservation and short, single-segment conduits.[1] They found that a conduit with a diameter <1.2 cm produced better long-term outcomes.[1] The cumulative graft patency rate was 70% over 3 years; additionally, they had no late structural changes of their grafts, and minimal venous morbidity.[2] Benjamin et al[7] performed an analysis on using SFVs for patients with mycotic pseudoaneurysms. Five patients underwent iliofemoral bypasses using SFV. All were patent at 20 months, with no amputations and no venous morbidity. Ehsan and Gibbons,[11] Dorweiler et al,[12] and Meneghetti et al[13] all had positive experiences using SFVs for cross-pelvic femoral-femoral bypasses. All three studies demonstrated patent grafts at the end of their respective follow-up periods and no amputations. Meneghetti et al[13] had the larger series where 20 patients underwent cross-pelvic femoral-femoral bypasses with SFV for either infected graft (12) or ischemia (eight). At the conclusion of their study, all grafts were patent (follow-up period of 6.25 years, mean of 24.3 months), and there was no requirement for graft revision.

Our results for patients undergoing LE arterial reconstructions using SFV are comparable. At 3 years, our primary, assisted primary, and secondary patency rates were 88.3%, 100%, and 100%. Our limb salvage rate was 90.5% at 3 years. For LE reconstructions performed in a noninfected field, SFV was preferentially used over prosthetic grafts, because these grafts have been more resistant to the development of intimal hyperplasia in our experience. These results corroborate that the SFV is a reliable conduit for LE arterial reconstructions, including iliofemoral and cross-pelvic femoral-femoral bypasses and femoral interposition grafts, for varied indications.

The SFV graft has also proven to be an excellent conduit for constructing LE AV fistulas when other conventional access sites have been exhausted. A meta-analysis conducted by Antoniou et al[14] looked at the outcomes of SFV transposition for AV fistulas as compared with upper-thigh and midthigh AV grafts. Primary patency rates at 1 year ranged from 73% to 93%; secondary patency rates at 1 year ranged from 86% to 100%. These rates were higher than those of either upper-thigh or midthigh AV grafts. One disadvantage noted, however, was the significantly higher rate of ischemic complications due to steal when using an SFV graft (ranging from 0% to 33% of patients). Gradman et al[15] described tapering the SFV graft at the takeoff from the distal femoral artery, as an operative technique that helped reduce ischemic complications.

Our experience with transposed SFV AV fistulas was comparable to other groups, both in terms of patency and ischemic complications. At 3 years, our primary, assisted primary, and secondary patency rates were N/A, 100%, and 100%, respectively. Our limb savage rate was 100% at 3 years as well. Only one patient suffered steal syndrome, which was corrected by performing a distal revascularization and interval ligation procedure using a femoral above-knee popliteal artery bypass. After this, she had no further ischemic symptoms and had a well-functioning fistula.

Central venous reconstructions have also been performed with SFV. Hagino et al[16] conducted a case series in which four of their seven patients underwent such reconstructions, including two innominate vein-to-right atrial appendage bypasses; one internal jugular vein (IJV) interposition graft; and one axillary-to-IJV bypass. The indication for surgery in three patients was due to tumor that had encased their deep central veins. One patient had a subclavian stenosis due to a dialysis line, requiring an axillary-to-IJV bypass. All bypasses were patent for their respective courses of follow-up (2 weeks to 34 months), and none of these patients suffered any venous morbidity.

We had four patients undergo central venous reconstructions with SFV. Two patients underwent a subclavian-to-innominate bypass. The indication for the first patient was venous thoracic outlet syndrome; her graft occluded after 5 years. The second patient underwent this due to tumor encasement of the central veins; the graft required both angioplasty and stenting of an extrinsic scar 2 months postsurgery but remained patent for the entire 2.5 years of follow-up. Two patients underwent their bypasses for SVC syndrome. The patient who had undergone an axillary-to-innominate bypass occluded his graft after 2.5 years and could not be recanalized. The second patient, who had undergone an innominate-to-SVC bypass, occluded within 1 month of its creation and could not be recanalized. Although three grafts did ultimately occlude, the majority of grafts remained patent for a comparable time period ranging from 2.5 to 5 years.

Reconstruction of the innominate, common carotid, and subclavian arteries has also been performed with SFV for neurologic, ischemic, and aneurysmal symptoms. Modrall et al[17] followed 71 patients who had undergone different combinations of these bypasses. Primary patency was 92% at 4 years, and assisted primary patency was 100%. Our series only had one patient, who underwent a CCA-to-vertebral bypass for a stroke due to an occluded vertebral artery. SFV was chosen as she had no suitable arm or leg veins; the graft was a suitable size match as well. Her neurologic symptoms improved, with no further sequelae. This graft was followed for 5 months and was patent during this entire period. Although our sample size is quite small, the success of this reconstruction as well as the work by Modrall et al[17] warrants further investigation of the SFV as an appropriate conduit for upper venous reconstructions.

The most common complication that occurred among all patients in our series was wound complications. Those who underwent LE procedures had the highest frequency of wound complications (13; 41.9%). Only two of these patients had serious wound complications; both had infected lymphoceles requiring debridement and muscle flaps. The remaining patients convalesced with conservative management alone. None of these patients had an exposed graft. Interestingly, nine of the 13 patients with wound complications presented with infected grafts before surgery, including the two patients with serious wound complications. Although the majority of wound complications did not involve infections, the initial presence of infection may have negatively affected wound healing. Not many studies delineated their experience with wound complications, so there are few available comparisons. Schulman et al[3] stated that 12.3% of their patients' pool had lymphoceles and lymphorrhea but ultimately was of little clinical significance.

Our series also demonstrated that SFV harvest could be tolerated with little venous morbidity. Wells et al[18] conducted a study specifically evaluating donor limbs after SFV harvest. None of their patients suffered any chronic venous changes. Twenty-two percent of their patients did experience DVT, but the majority involved the popliteal vein stump; these patients were not treated with anticoagulation. Among our study group, only one patient had a postoperative DVT, which involved the popliteal vein and calf veins. This patient was treated with anticoagulation and convalesced well. Venous duplex scans were not routinely performed in the postoperative period, unless symptoms were present. In our follow-up, no patients had any long-term venous morbidity, including leg edema, and/or venous claudication. It is certainly possible that there were silent DVTs; however, we did not see any clinical sequelae in our patients. This may be because of our efforts to preserve the GSV during harvest of the SFV.

The major limitations of this study would be the small size in two of the study groups and limited follow-up intervals in certain patients. We had small numbers of patients in our venous and upper arterial bypass groups due to the rarity of this pathology. The small n values limited us from performing complex statistical analyses to make meaningful comparisons. Additionally, certain patients had short follow-up intervals because they were from out of state and continued their postoperative follow-up in their local vicinity. This may have under- or overestimated the longevity of their graft patencies. Similarly, postoperative complications in patients lost to follow-up may have been underestimated because they were not reported in our database. Finally, generalizations drawn from our pooled and venous estimates of patency, limb salvage, and survival must be drawn with the caveat that the study groups were heterogeneous, as they included different types of reconstructions.

CONCLUSIONS

The SFV can be a versatile conduit for both arterial and venous reconstructions when the GSV is unavailable or of poor quality with excellent graft patency rates. Transposed SFV arteriovenous fistulas are another efficacious SFV reconstruction with excellent patency rates. SFV harvest is associated with minimal venous morbidity in the donor limb-making this a safe option. The only caveat is that patients undergoing SFV reconstruction who present with an infected graft may be at higher risk for developing a postoperative wound complication.

AUTHOR CONTRIBUTIONS

Conception and design: SB, TS, DC
Analysis and interpretation: SB, TS

Data collection: SB
Writing the article: SB, TS
Critical revision of the article: SB, TS
Final approval of the article: TS, DC
Statistical analysis: JB
Obtained funding: TS, DC
Overall responsibility: SB, TS

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